A new perspective on the raindrop size distribution and its implications for retrievals of light rain

Patrick N. Gatlin, NASA Marshall Space Flight Center

Merhala Thurai, Colorado State University

Walter A. Petersen, NASA Marshall Space Flight Center

V. N. Bringi, Colorado State University

Matthew Wingo, University of Alabama in Huntsville

American Geophysical Union Fall Meeting 2017
New Orleans, December 13th

H33J-03

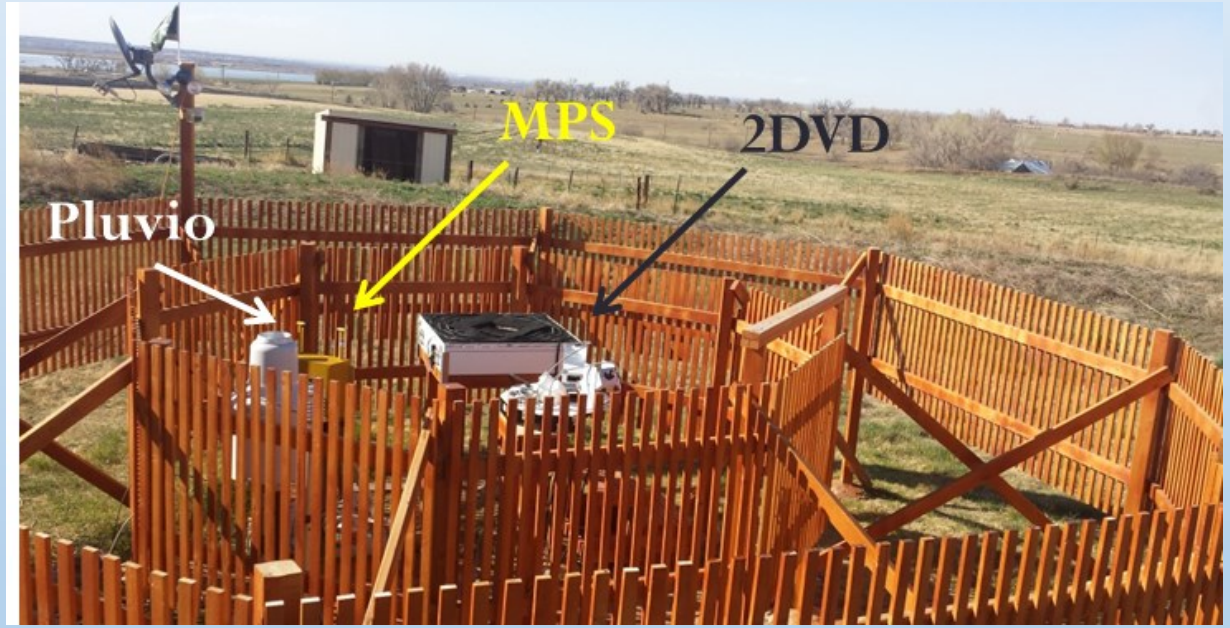
Why are we doing this?

- GPM retrievals in light rain
  - Minimum detectable by DPR: 13 dBz (Ku) & 12 dBz (Ka-HS)
    → 0.5 and 0.2 mm/hr (Hou et al. 2014; Toyoshima et al. 2015)
    → 43.1% and 11.3% of precipitation events (Lin and Hou 2012)
  - Minimum detectable by GMI: 0.17 mm/hr (ocean) 0.38 mm/hr (land) (Munchak and Skofronick-Jackson 2013)
- Impact of small drops on DSD parameters
  - D_m significantly lower at light rain rates
  - N_w significantly larger

  (based on a few cases presented in Thurai et al. 2017, JAMC)
- Disdrometer size range limitations cause problems for the gamma model to describe the DSD at both tails of the raindrop size spectrum

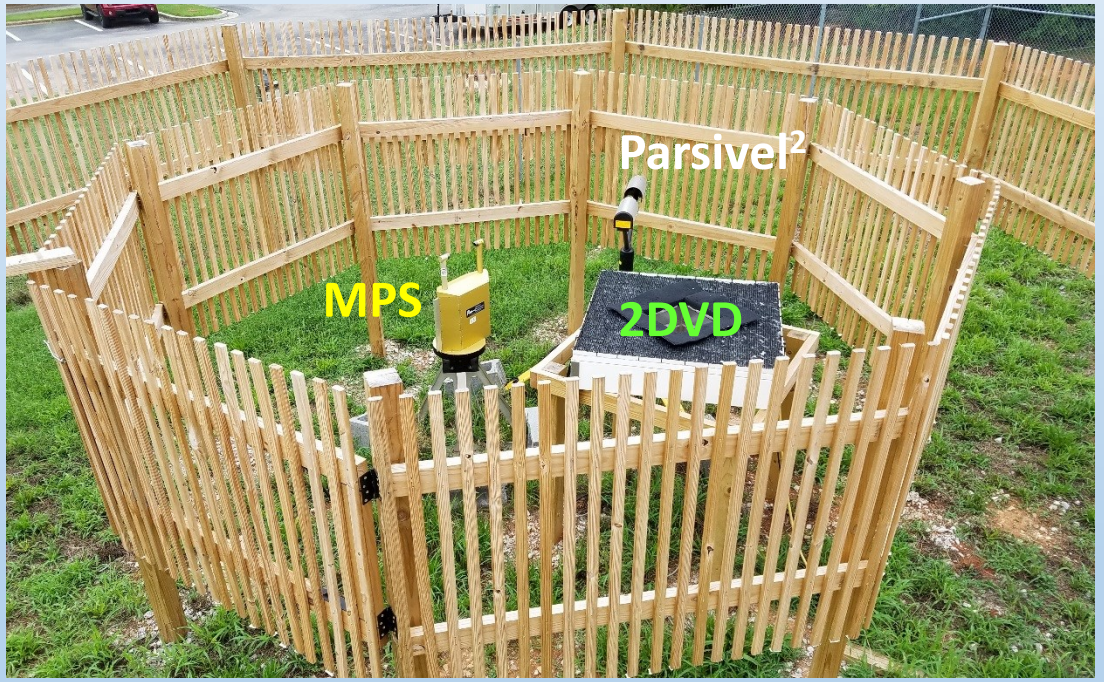
Experimental Setup

Easton, Colorado (near CSU-CHILL)



Climate: Semi-arid (Köppen–Trewartha)
April-October 2015
13 rainfall days (documented)

Huntsville, Alabama

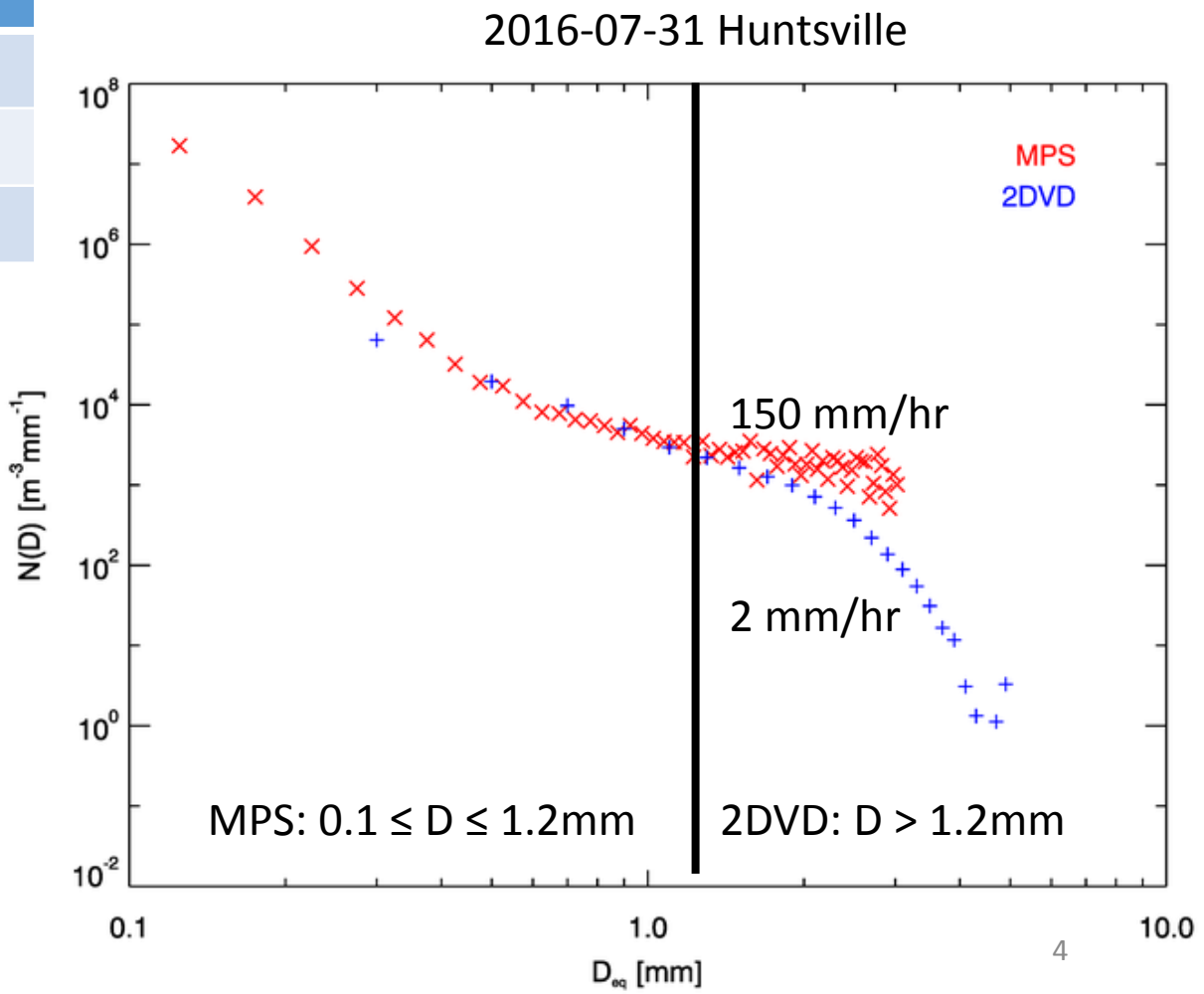


Climate: Humid subtropical (Köppen–Trewartha)
Number of DSD minutes: 7,692
March 2016-June 2017 (ongoing)
41 rainfall days

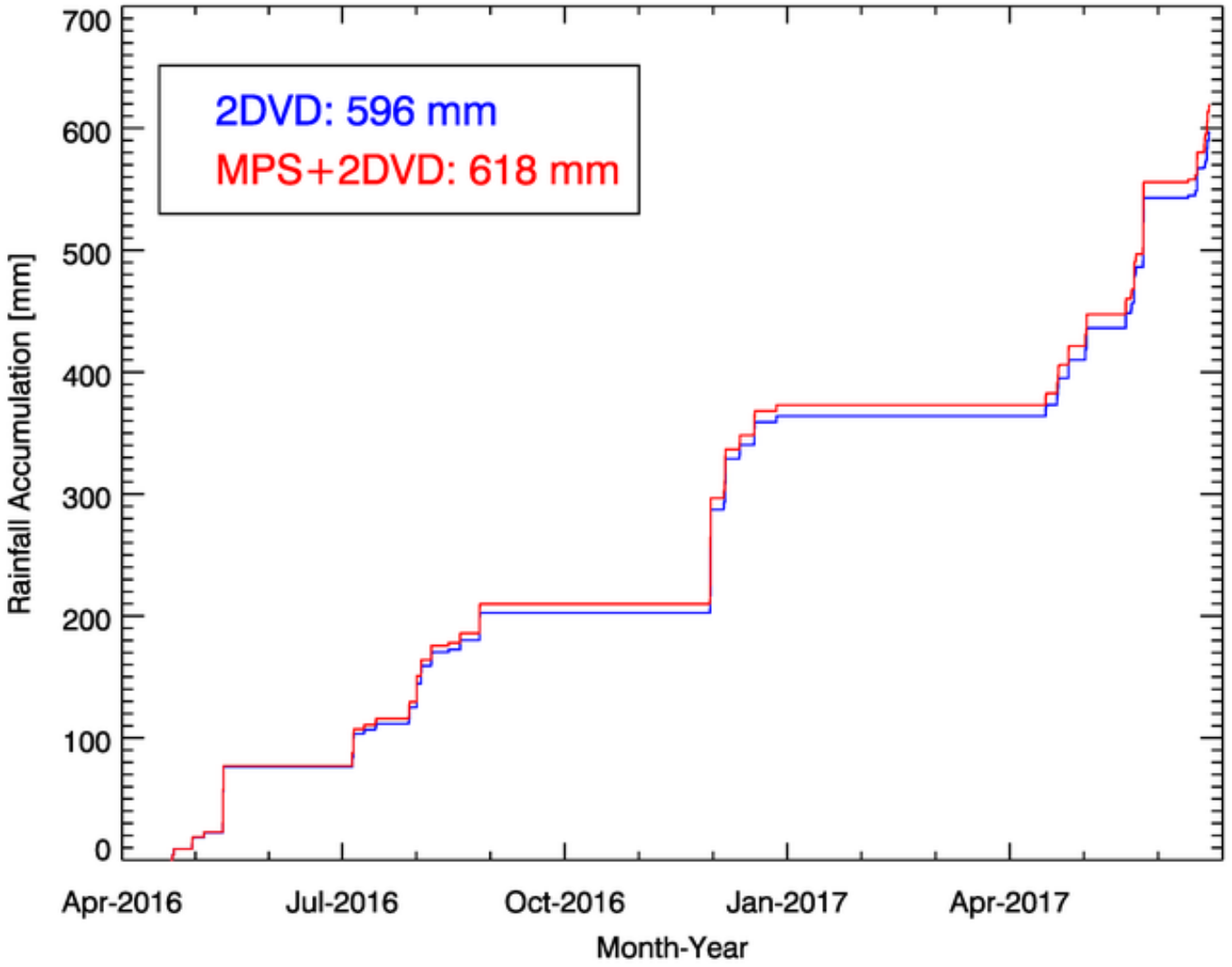
Combining the MPS and 2DVD

Parameter	MPS	2DVD
Horizontal Resolution	50 µm	170 µm
Measuring Area	20 x 3.1 cm	10 x 10 cm
Size range	50 µm-3.1 mm	> 0.6 mm

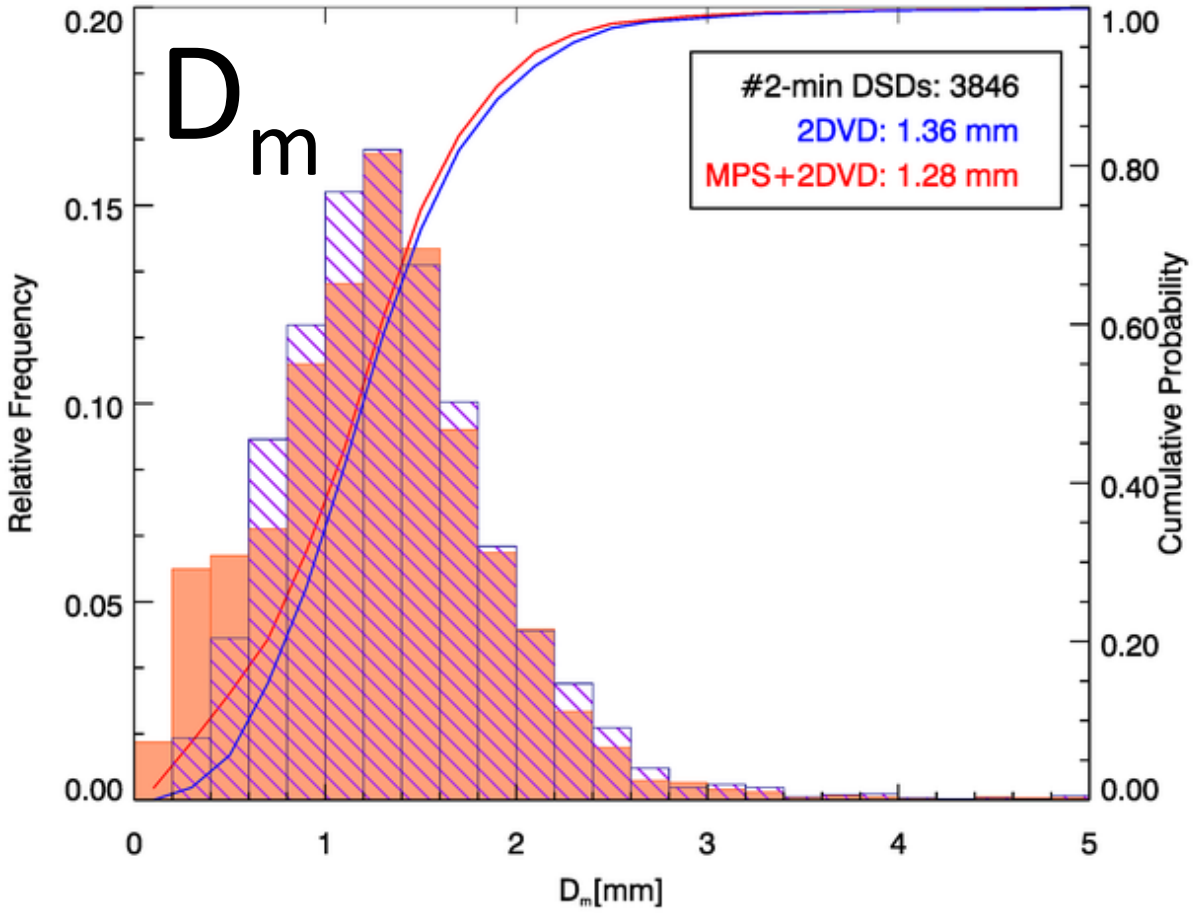
- Better resolve the tails of the DSD, especially the small drops
- Good agreement between MPS and 2DVD in overlap region
- Combined DSD:
  - MPS: 0.1 ≤ D ≤ 1.2mm
  - 2DVD: D>1.2mm

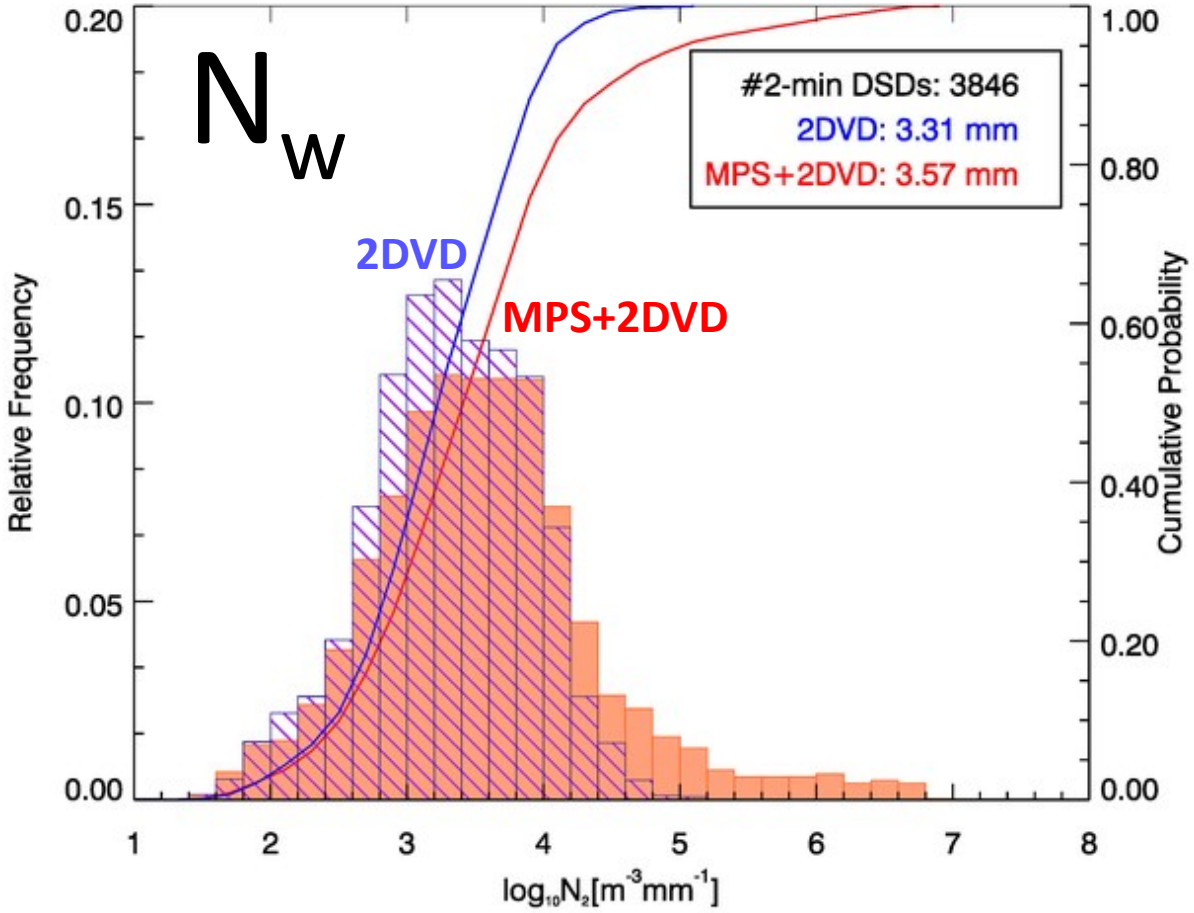


Summary of Rainfall events from Huntsville



Huntsville, Alabama DSD parameters

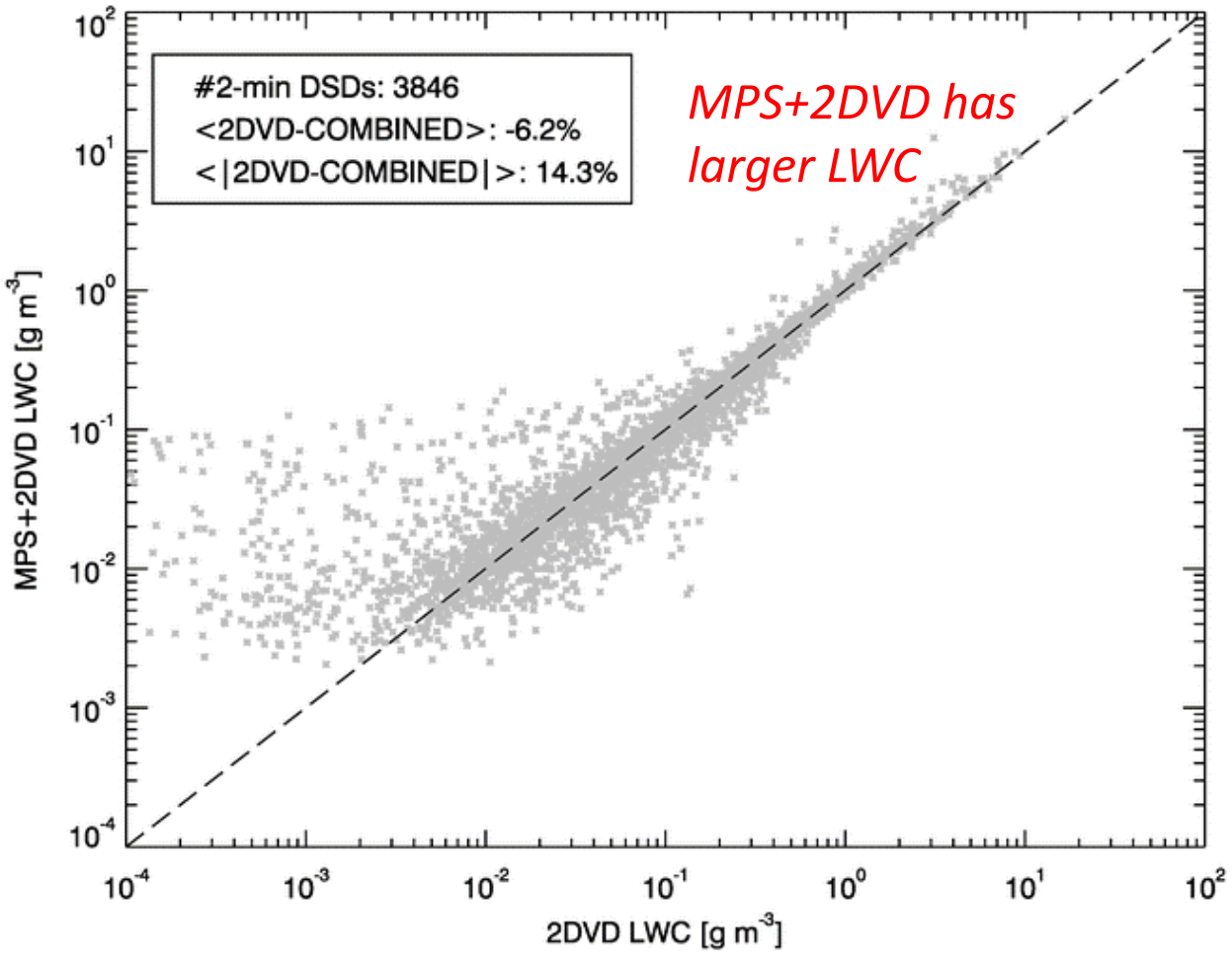


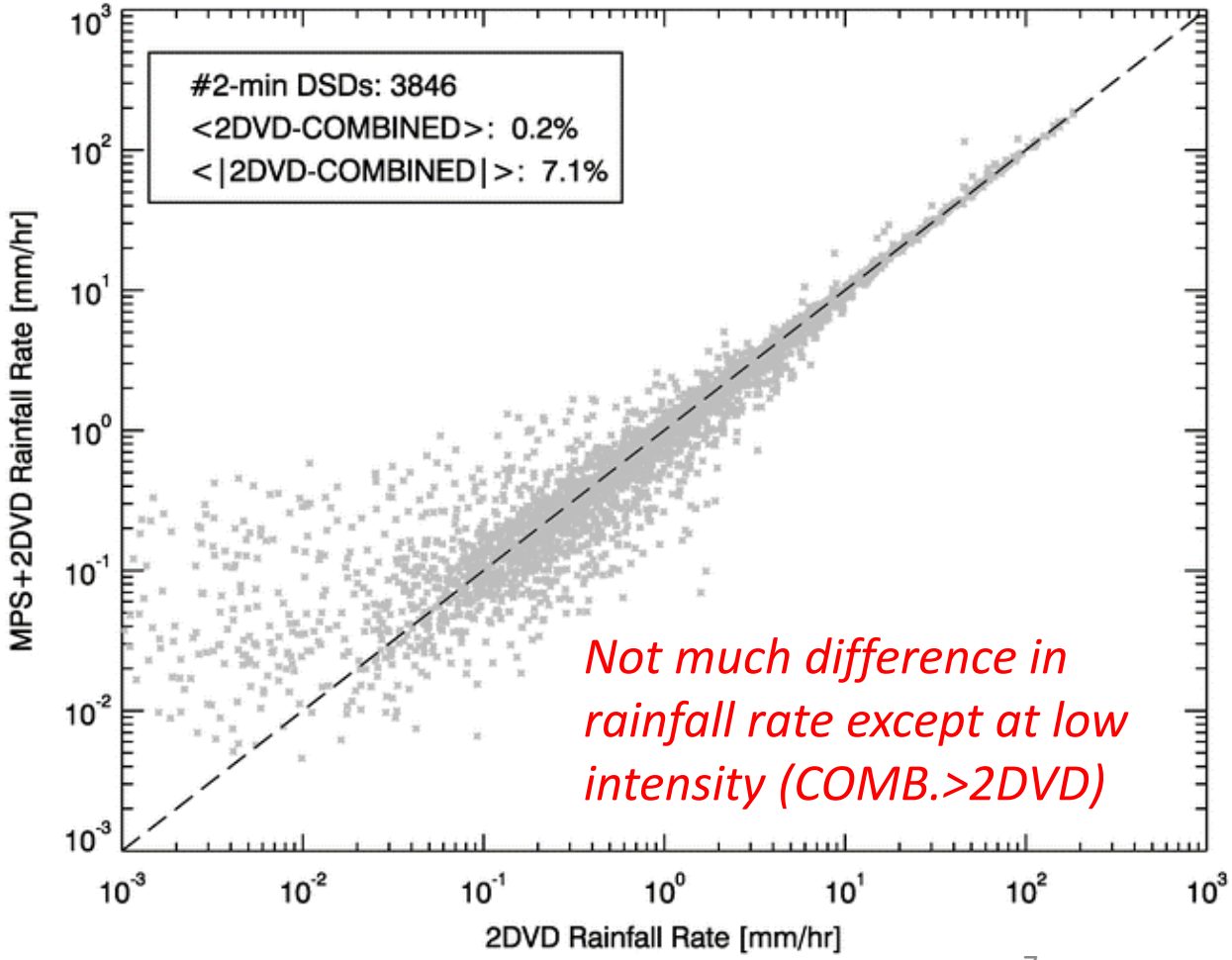


D_m for combined MPS+2DVD is <u>smaller</u> than 2DVD alone

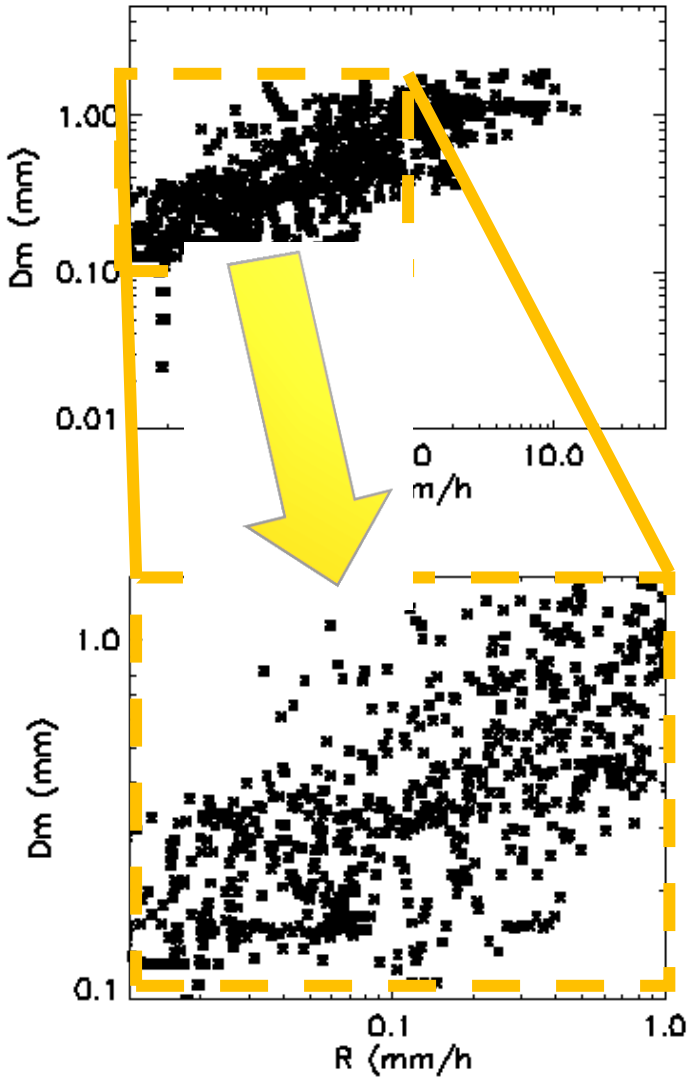
N_w for combined MPS+2DVD is <u>larger</u> than 2DVD alone

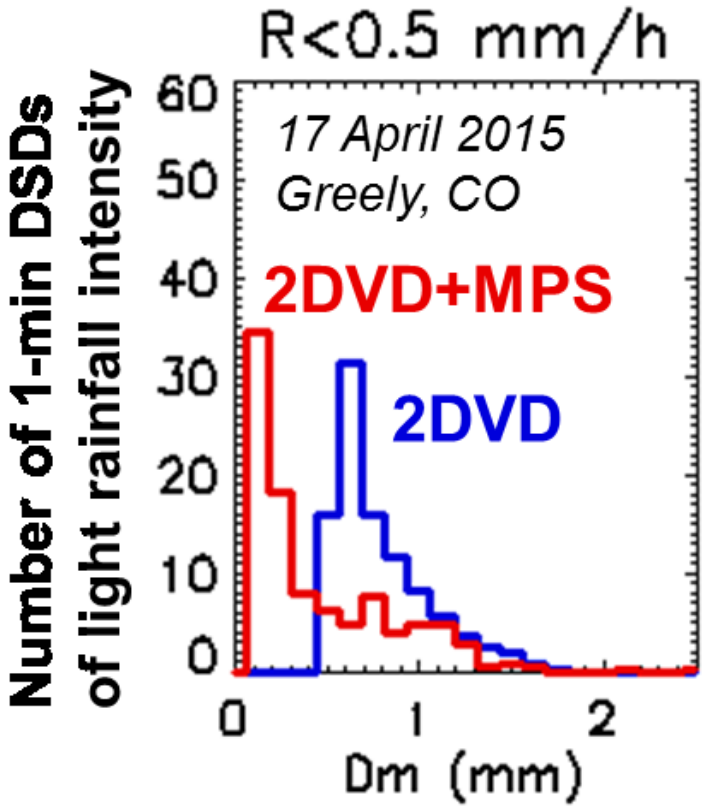
Small drops add more water to the DSD





What happens to D_m at light rainfall rates?

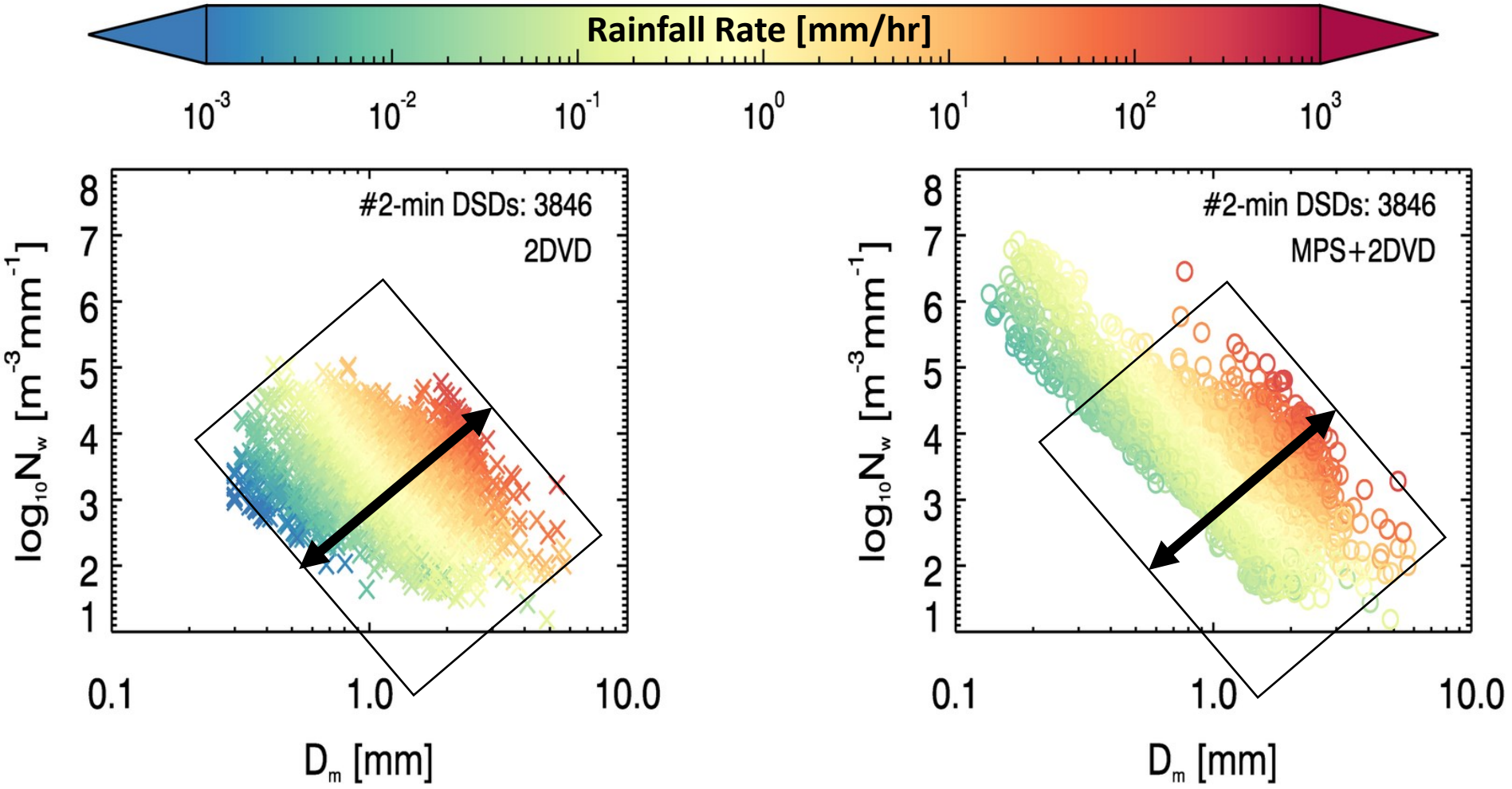




At light rainfall rates, the MPS+2DVD D_m is much smaller than that from the 2DVD

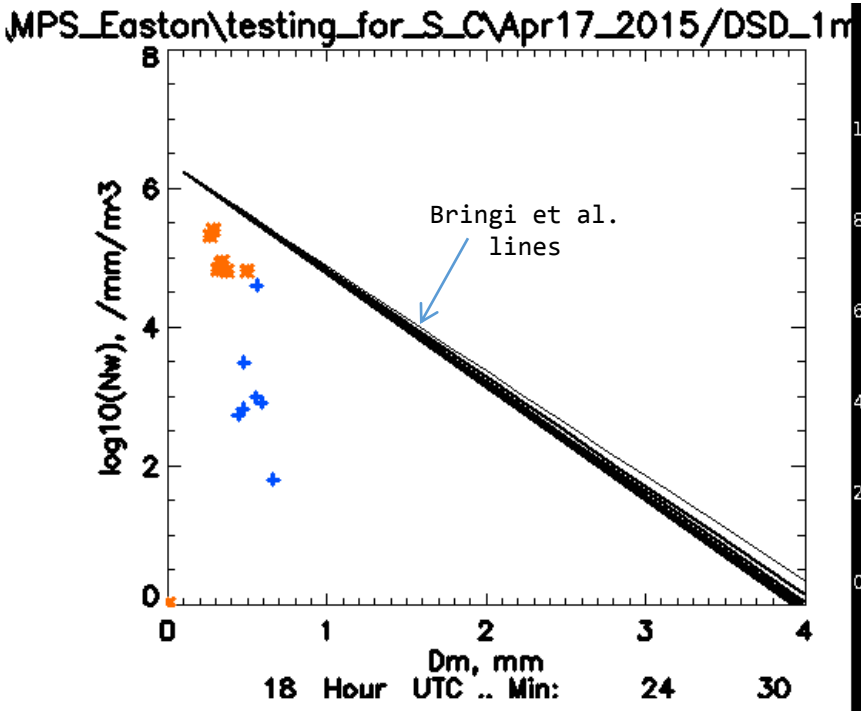
17 April 2016: Easton, Colorado

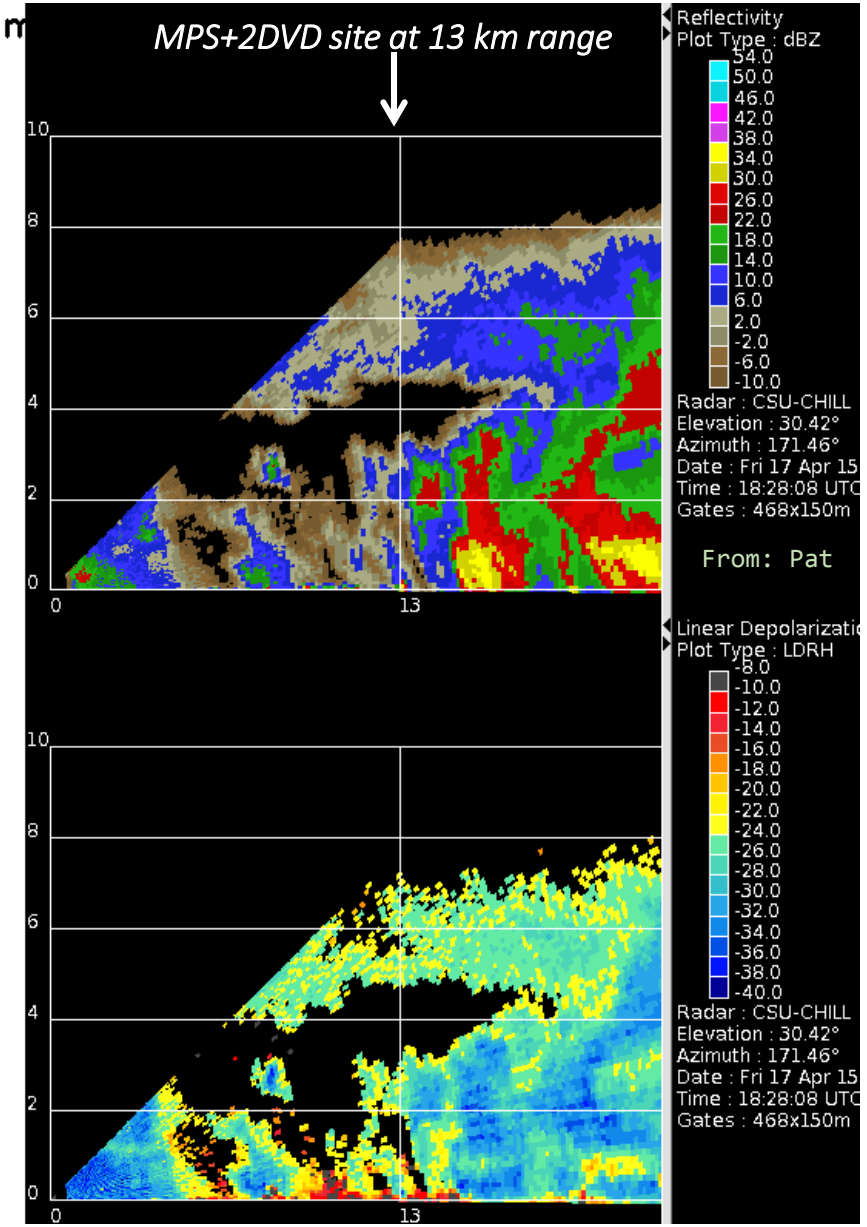
How does it affect N_w- D_m variability?



→ ***Less variability when small drops are included***

How does this affect Convective-Stratiform Partitioning





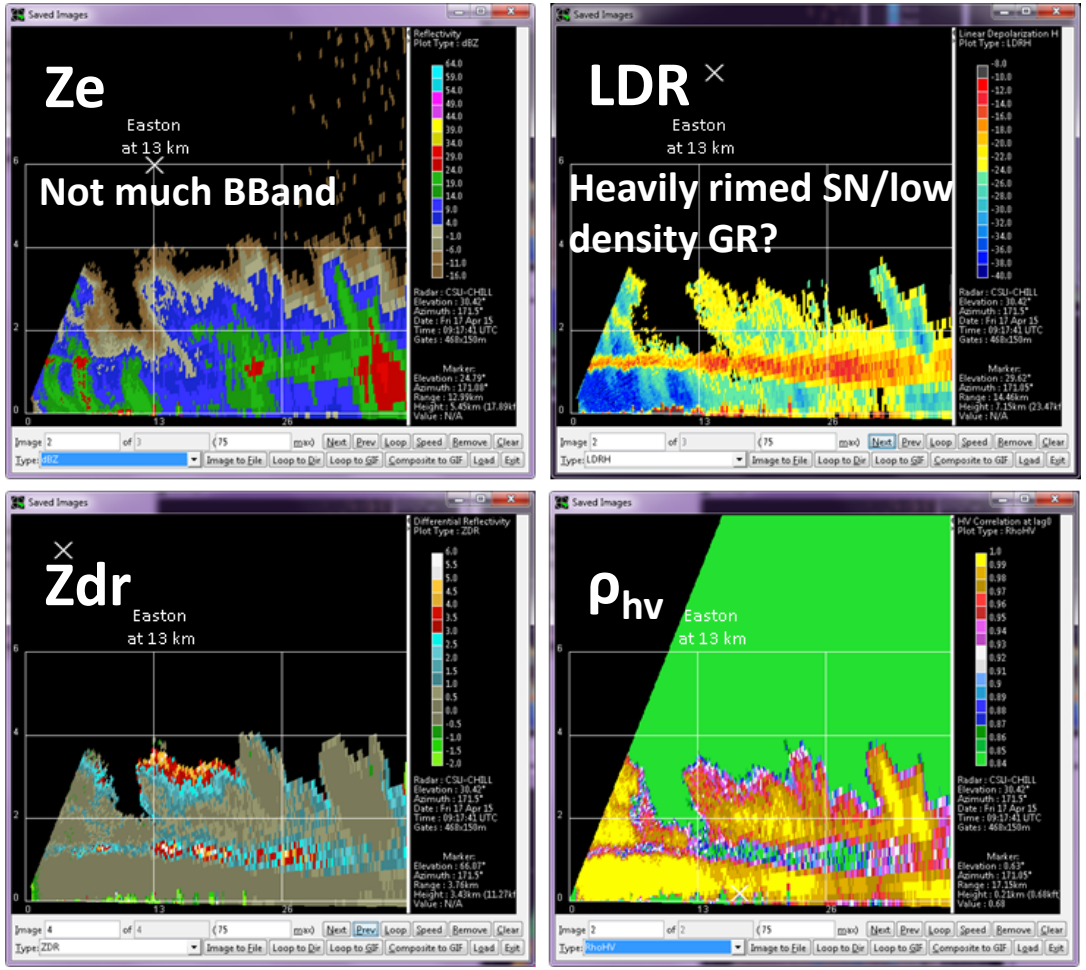
Loop with N_w-D_m from 2DVD and MPS+2DVD; synchronized with CHILL RHIs of dBZ and LDR, 1824 – 1924 UT. Every 6 minutes.

Note the jump over the set of lines during the passage of the convective storm at around 18:55 UTC.

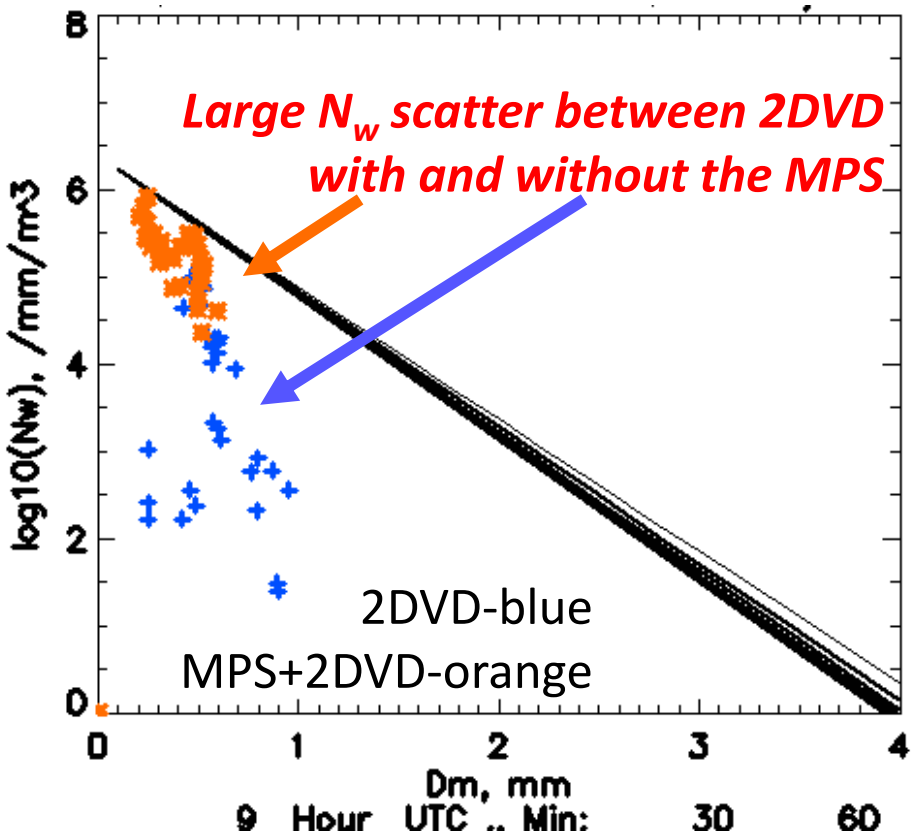
Also a weaker one at 18:40 where some points lie on the lines.
(Animations courtesy Pat Kennedy, CSU CHILL)

Stratiform Precipitation

CHILL Radar RHI Scans over MPS+2DVD



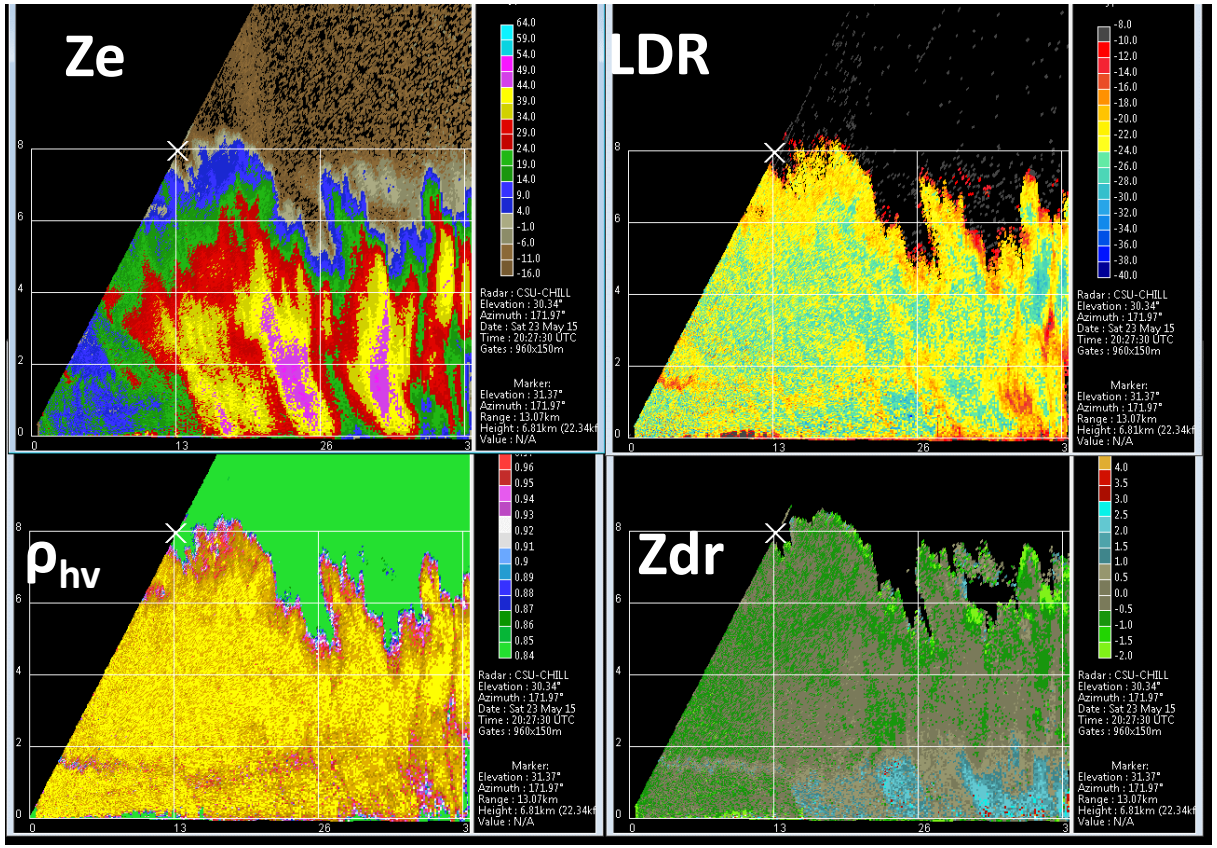
Easton, Colorado



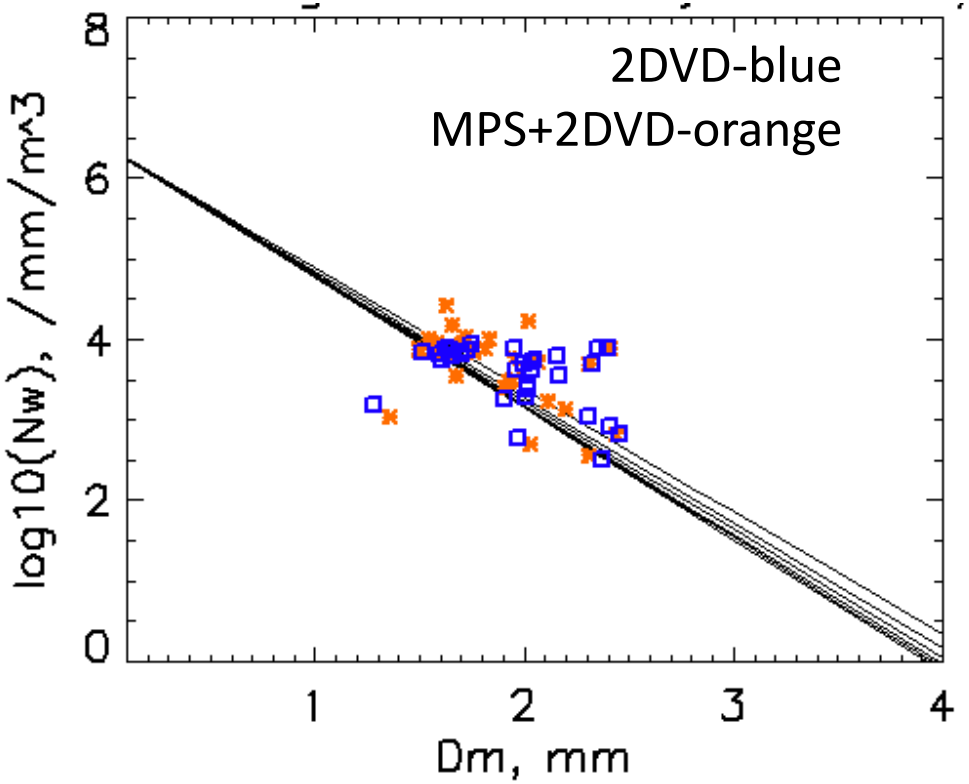
DPR would likely misclassify this as convective (e.g., Houze 2017 PMM)

Convective Precipitation

CHILL Radar RHI Scans over MPS+2DVD

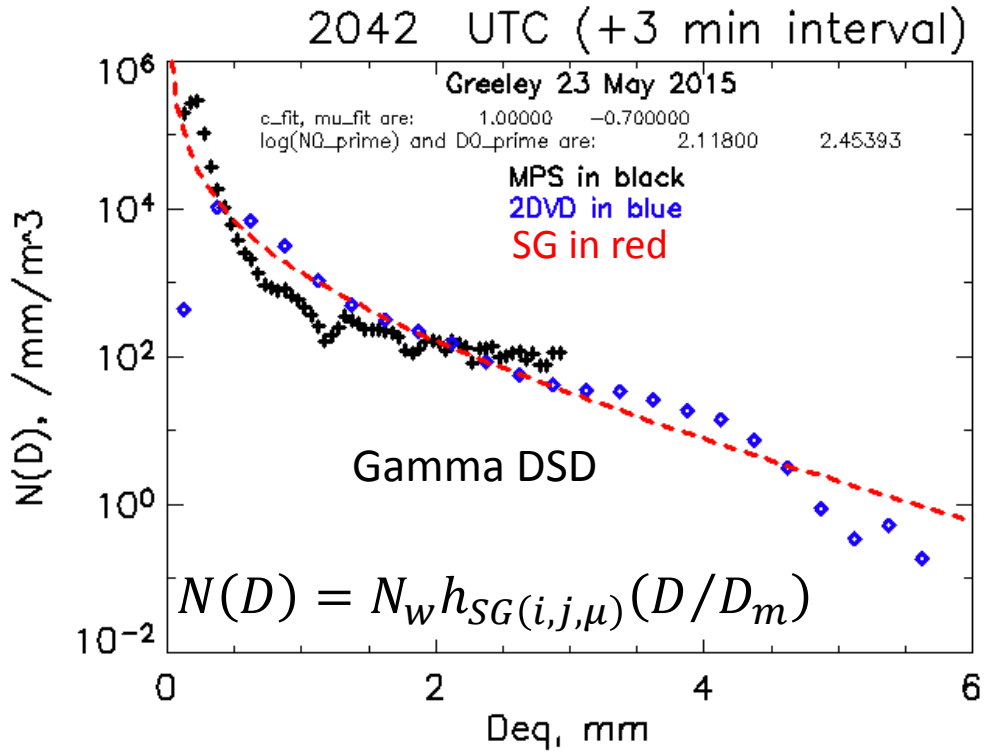


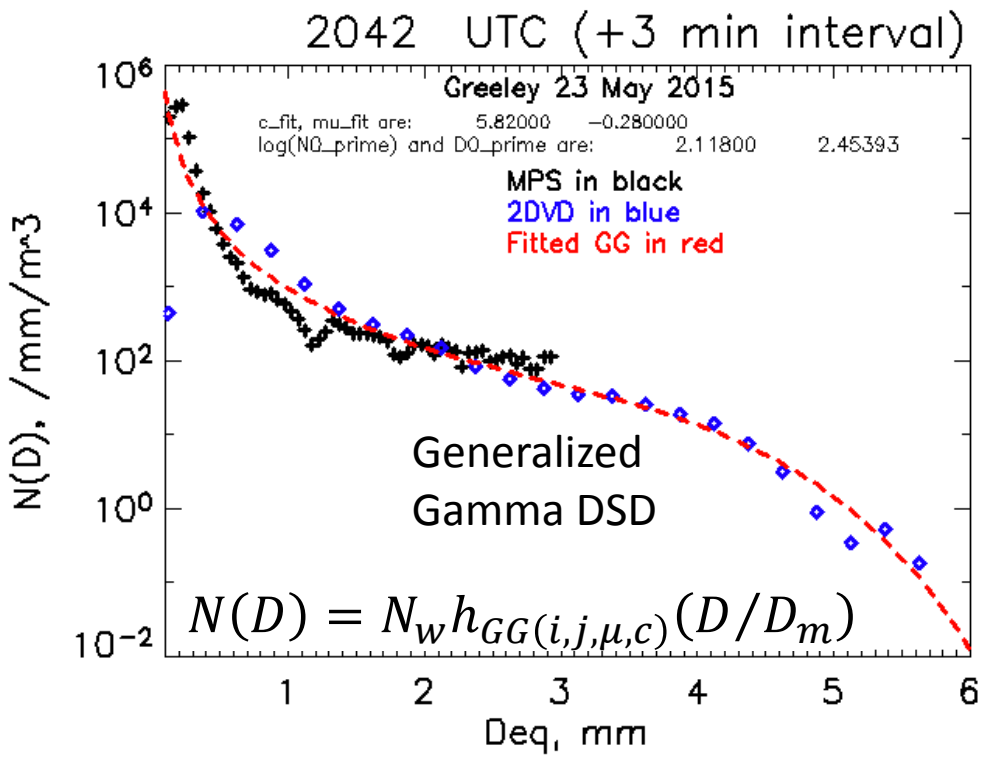
Easton, Colorado



Much closer DSD agreement for convective period

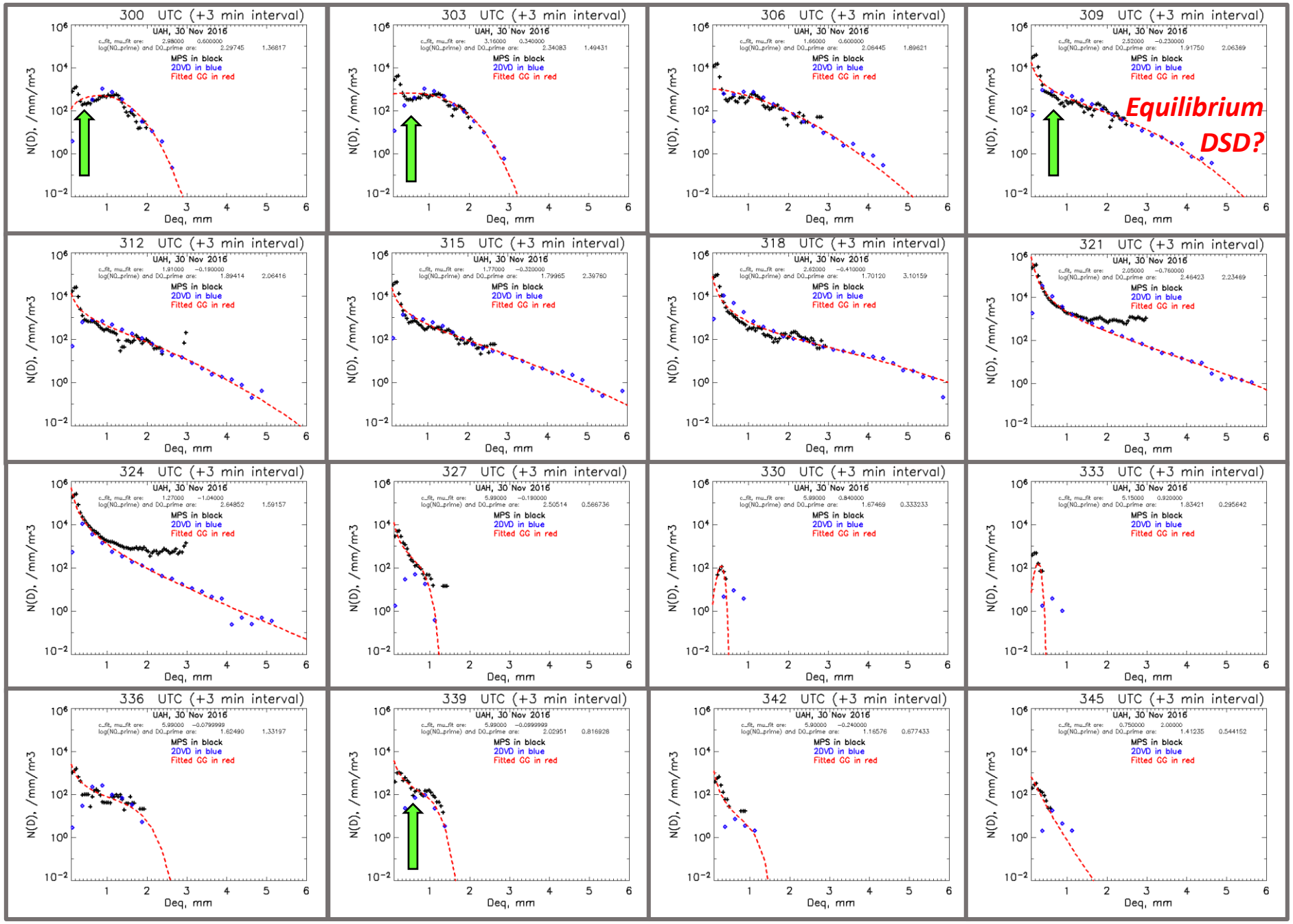
Why the generalized gamma?





→ ***Generalized Gamma provides a better fit across the DSD spectrum, especially at the tails (Thurai and Bringi 2017, in review)***

(see also Lee et al. 2004; Raupach and Berne 2017, JAMC)



30 November 2016
Huntsville, Alabama
3-minute DSDs

Bi-modal DSDs

<u>3 regions of DSD:</u>

1. Drizzle mode $D_{eq} < 0.7$ mm
2. Plateau region
3. Precipitation mode $D_{eq} > 1$mm

What are the implications for retrieving light rain from GPM?

- Small drops affect the DSD parameters, especially for light rainfall
- Also affect the DSD-based partitioning of Convective-Stratiform
- Generalized gamma accounts for bi-modality of the DSD (i.e., drizzle and precipitation portions, including the plateau/shoulder region) and provides better fit at the tails

→ G-G model may provide a better retrieval/validation of light rainfall (R, D_m and N_w), but need to further examine variability of shape parameters $N(D) = N_w h_{GG(i,j,\mu,c)}(D/D_m)$

Acknowledgements

- A portion of this work was funded by Dr. Ramesh Kakar through NASA's Precipitation Science Mission
- M. Thurai and V.N. Bringi also acknowledge support of the National Science Foundation Award #1431127 - AGS (Atmospheric and Geospace Sciences), Atmospheric & Geospace Sciences Division